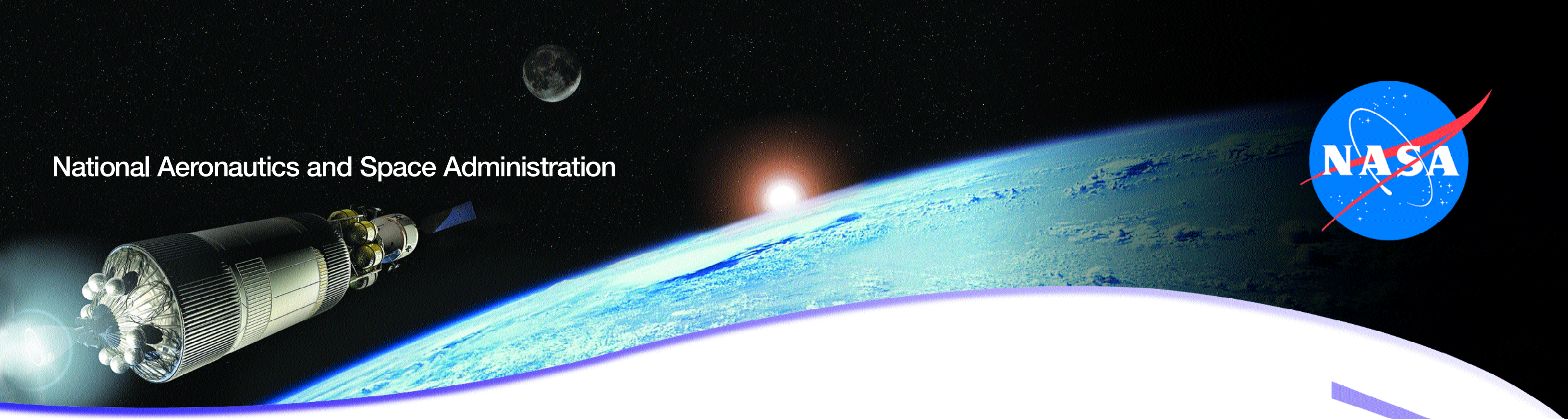

goddard technology

Carbon Nanotubes

Building an Electron Gun

About the Technology

NASA's emphasis on smaller spacecraft for solar-system exploration demands low-cost, high-performance instrument payloads. To miniaturize the next-generation mass spectrometer, Goddard technologists are developing new technologies to reduce the size of the instrument's ion-source assembly, a critical component needed to ionize gas molecules so that the instrument can measure the molecules' mass spectra.

They are developing an electron gun constructed in part of patterned towers of carbon nanotubes (CNTs). Applying an electrical field to the CNTs produces an electron beam. The beam removes an electron from the gas molecules under study through electron impact, thus ionizing them.

Below: Principal Investigator Stephanie Getty is exploring the use of nanotechnology to miniaturize the next-generation mass spectrometer. She has developed patterned towers of nanotubes (right) that could be used in the mass spectrometer's electron gun, the device that ionizes gas molecules.

Significance of the Technology

Carbon nanotubes used as field emitters are more efficient than the more traditional thermionic technology, which requires at least 100 times more power and the use of a macroscopic filament. In addition, the electron gun produces an electron beam at ambient temperatures with less than 1 mW of operating power. Compared with a thermionic emitter, the electron gun is smaller, currently measuring 1 cm in width, height, and depth, and can be scaled down to micron dimensions.

One of the disadvantages of conventional electron-gun technology is lifetime and robustness. Preliminary tests indicate that the lifetime of Goddard's CNT emitters is competitive with conventional technology. Its robustness to mechanical and chemical degradation will be verified through testing.

See reverse side

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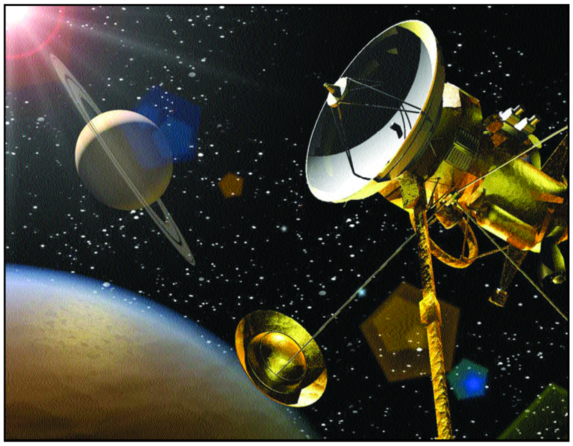
Benefits of the Technology: At-A-Glance

- Operates at ambient temperatures.
- Offers potential to significantly reduce the size of electron-impact-ionization mass spectrometry.
- Measures only 1 cm in width, height, and depth and can be scaled down to micron dimensions.
- Produces an electron beam with less than 1 mW of operating power.

Technology Origins

The Ames Research Center, in collaboration with Goddard technologists, produced uniform films of CNTs to demonstrate the electron-gun concept. While these samples produced an electron beam, researchers discovered that the patterned arrays of CNT towers, which a Goddard technologist had created under R&D funding using the Materials Engineering Branch's chemical vapor deposition growth furnace, performed even better. Since then, Goddard technologists have further refined and matured their technology, fabricating the first prototype of an electron gun with an integrated lens stack.



The Goddard-developed mass spectrometer that flew on the Cassini-Huygens mission to Saturn, which is pictured here, was roughly the size and weight of a bowling ball. The goal is to reduce the size of time-of-flight mass spectrometers so that they consume less power than a clock radio and are about the size of a CD case.

Enhanced Capabilities

Development activities over the coming year include improved packaging, life-testing in various gases to determine robustness, and an investigation into microsecond-scale switching of the electron beam.

Looking Ahead

Technologists are working with Goddard's mass spectrometer development team to integrate the CNT electron-gun technology into an instrument prototype within the next year. They also have discussed possible applications as the excitation source of a handheld X-ray fluorescence instrument for planetary and lunar science.

Comparison of CNT Emitter with Traditional Electron-Gun Technology

Type Metric	CNT Feild Emitter	Thermonic Emitter
Density	10^{10}/cm2	1 /cm2
Redundancy (2mm x 2mm	10^{6}	1
Lifetime	> 450 hr @ 10^{-7} Torr	~ 100 hr @ 10^{-7} Torr
Power Consumption	0.8 mW	100 mW
Operating Temperature	Ambient	> 1000°C

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